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Title: Nuclear Material Measurement Contribution to the Material Balance Evaluation

Author(s): Geist, William H.

Intended for: Training Course

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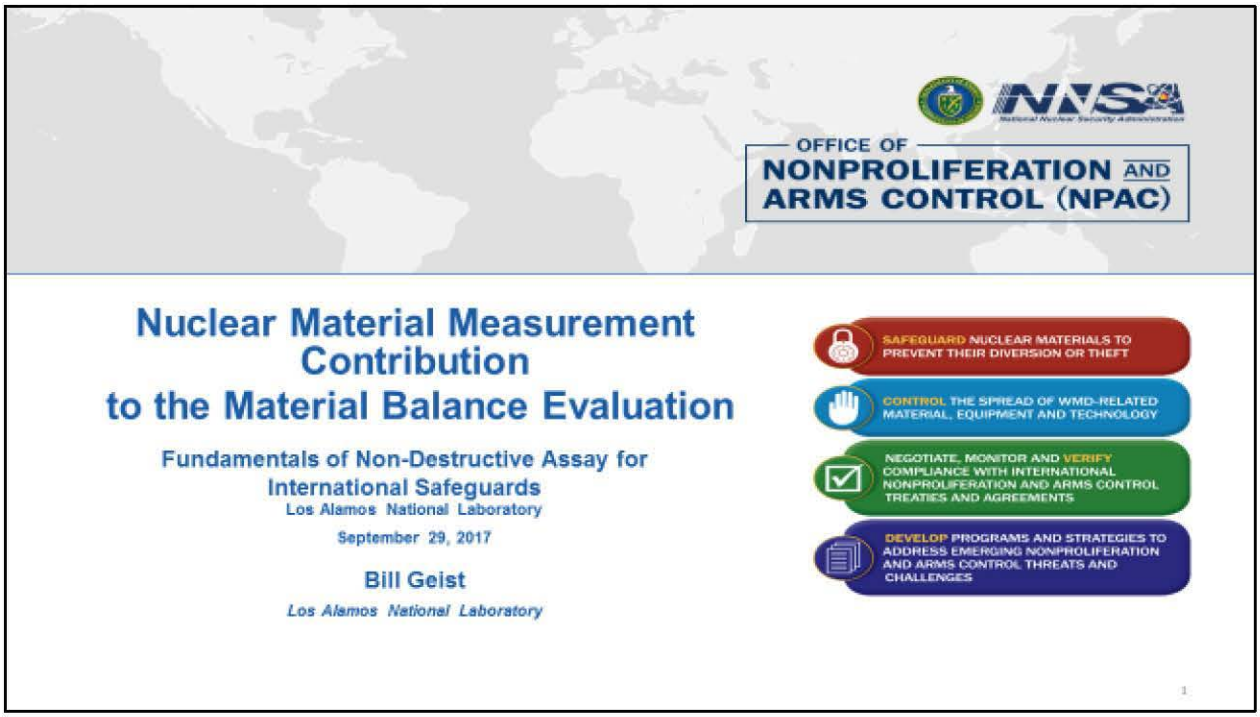
OFFICE OF
NONPROLIFERATION AND
ARMS CONTROL (NPAC)
Nuclear Material Measurement
Contribution
to the Material Balance Evaluation
Fundamentals of Non-Destructive Assay for
International Safeguards
Los Alamos National Laboratory
September 29, 2017
Bill Geist
Los Alamos National Laboratory
SAFEGUARD NUCLEAR MATERIALS TO PREVENT THEIR DIVERSION OR THEFT
CONTROL THE SPREAD OF WMD-RELATED MATERIAL, EQUIPMENT AND TECHNOLOGY
NEGOTIATE, MONITOR AND VERIFY COMPLIANCE WITH INTERNATIONAL NONPROLIFERATION AND ARMS CONTROL TREATIES AND AGREEMENTS
DEVELOP PROGRAMS AND STRATEGIES TO ADDRESS EMERGING NONPROLIFERATION AND ARMS CONTROL THREATS AND CHALLENGES
1

Estimated Module Duration: 30 minutes

Required Tools and Materials:

1. Projector, screen, laptop with Word and PowerPoint programs
2. Participant guides, with slides and supplemental material

References:

1. INTERNATIONAL ATOMIC ENERGY AGENCY, IAEA Safeguards Glossary, International Nuclear Verification Series No. 3, IAEA, Vienna (2003). http://www-pub.iaea.org/books/IAEABooks/6570/IAEA-Safeguards-Glossary
2. INTERNATIONAL ATOMIC ENERGY AGENCY, IAEA Safeguards Technical Manual, Part F Statistical Concepts and Techniques, Volume 3, IAEA-TECDOC-261, IAEA Vienna (1982). http://www-pub.iaea.org/MTCD/publications/PDF/te_261_web.pdf

Supporting Documents:

1. None

Job Aids:

1. None

Terminal Learning Objectives (TLOs):

- TLO-1: Describe the impact that NDA measurements have on the material balance evaluation and the determination of MUF

Enabling Learning Objectives (ELOs):

- ELO-1: Discuss the role of measurements in the evaluation of a material balance
- ELO-2: State the material balance equation
- ELO-3: List the objectives in performing a material balance evaluation
- ELO-4: Describe the similarities and differences in performing a material balance evaluation between an item and bulk facility type
- ELO-5: Explain how sigma MUF is calculated and used in a material balance evaluation
- ELO-6: Discuss the role of operator's measurements and inspector's measurements in a material balance evaluation

Additional Information for Students:

Instructor Notes:

Review learning objectives with the participants.

Encourage participants to ask questions during the lecture.

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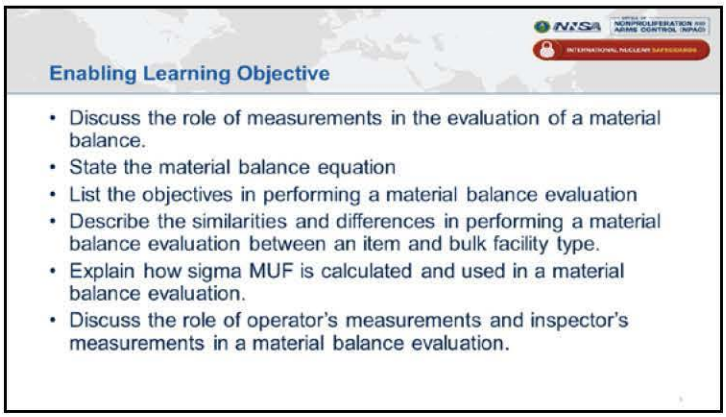

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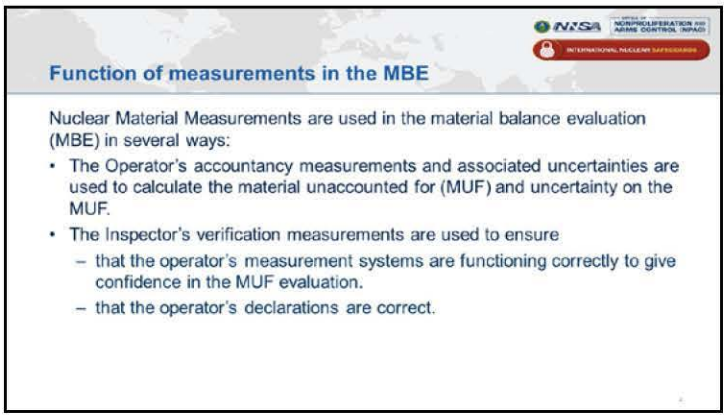

Measurements of nuclear material are a very important aspect in the material balance evaluation process. The measurements are used to ensure that the operator's measurements systems are in control. This will give greater confidence in the MUF and sigma MUF values generated during a material balance evaluation. Measurements are also used to ensure that the operator's declaration is correct.

Instructor Notes:

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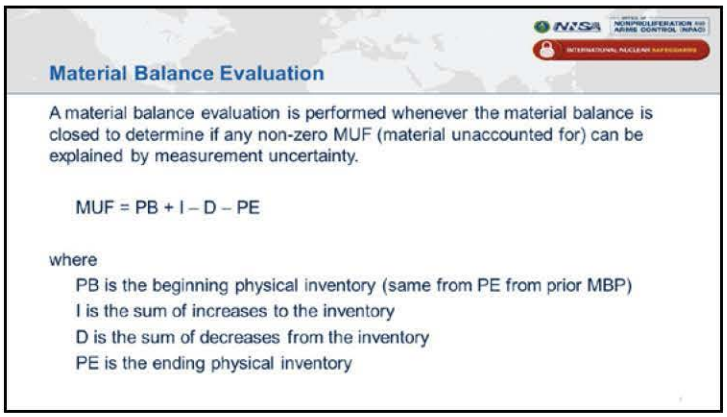

Instructor Notes:

In the material balance evaluation performed by the operator, the uncertainties associated with the measurement system used to determine the declared amounts of material, for each of the for components of the material balance equation, are applied to the item or stratum amounts to determine the uncertainty of the material balance. The operator uses the MUF and associated uncertainty for both safeguards, safety, and security goals. A zero MUF indicates that no material has gone missing or that there is no excessive holdup in the facility. The uncertainty on the MUF is also an indication that the measurement systems are performing within acceptable parameters.

The IAEA material balance evaluation includes: a) evaluation of the operator's declared MUF and the cumulative MUF, b) evaluation of the operator-inspector difference, c) evaluation of the inspector's estimate of MUF, d) comparison of sigma MUF with the international standards of accountancy to determine if the operator's measurement system is adequate for safeguards purposes.

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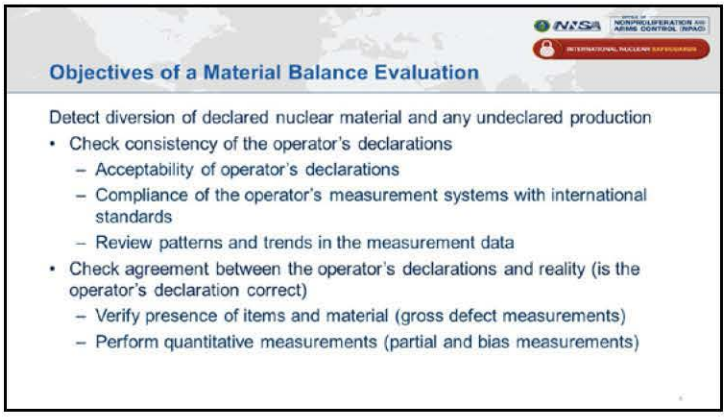

Instructor Notes:

To check the consistency of the operator's declarations, the IAEA will do a thorough review of the operator's books. This will ensure that the accounting records are reasonable to comparing record keeping documents and also ensure that the amount of material flow is in agreement with the design information of the facility. They will check to ensure that the operator's measurement systems are in control and yielding results that are acceptable when compared to international norms. The IAEA will review the patterns in the MUF, CMUF, and sigma MUF values over many material balances to ensure agreement with normal statistical fluctuations. The IAEA will also perform measurements to ensure the correctness on the operator's declaration. The type and number of measurements is based on a sampling plan.

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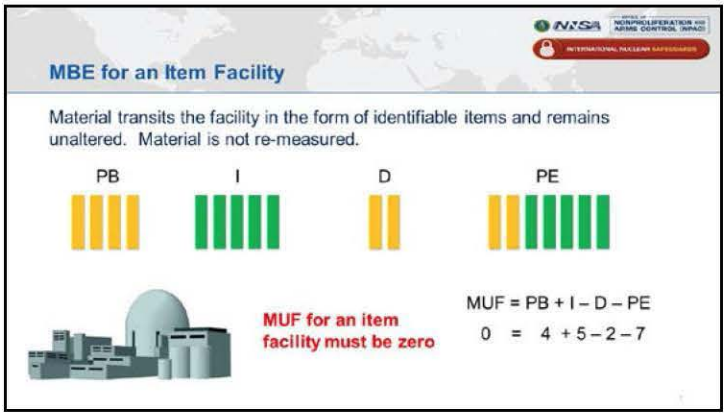

Instructor Notes:

This is a simple example of a material balance evaluation of a power reactor. The yellow items could be fuel assemblies already located at the facility at the beginning of the material balance period (MPB) and the green items are new assemblies delivered to the facility during the MBP. In this example, 4 items were at the facility at the start of the MBP, 5 new assemblies were delivered, and 2 assemblies were shipped off site during the MBP. At the end of the MBP, there were 7 assemblies remaining (2 yellow and 5 green). Putting these number into the MBE equation results in a zero MUF. Since in an item facility there is no processing of material the MUF is expected to always be zero.

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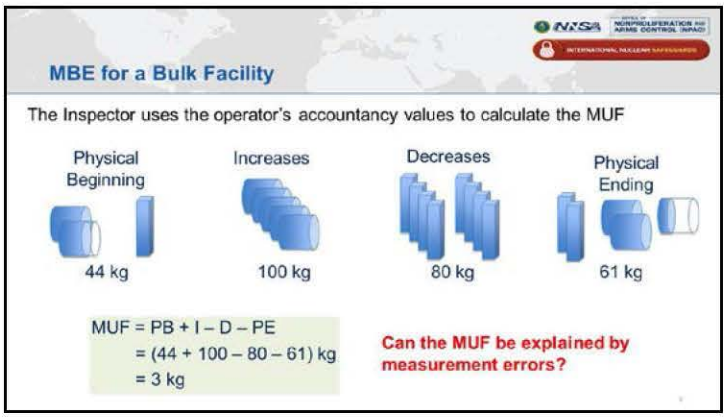

Instructor Notes:

The accountancy mass values are obtained from the operators accountancy measurements. Most of the accountancy measurements are based on both nondestructive and destructive assay techniques. Since all measurements have uncertainties, a non zero MUF is expected. In this example, 3 kg of material is missing. Is this material really missing or can it be justified as an uncertainty.

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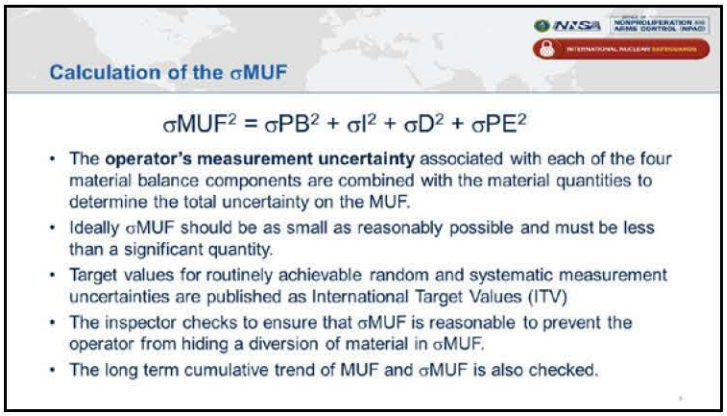

In the material balance evaluation, the uncertainties associated with the measurement system used to determine the declared amounts of material, for each of the four components of the material balance equation, are applied to the item or stratum amounts to determine the uncertainty of the material balance.

Diversion into MUF is a concealment method in which an amount of declared material M is removed from a material balance area and the accounting records are adjusted to account for the amount M removed. Because the operator's accounting records reflect the removal of M, there is no falsification of these records. This diversion strategy causes an imbalance in the MUF equation and the diversion amount M shows up as part of a non-zero MUF. The diverter assumes that the uncertainty of MUF would be large enough to hide the removal. This type of diversion would be detected through observation of an unusually large value of MUF. However, if sigma MUF is large because of poor measurement quality, then the diversion can be concealed.

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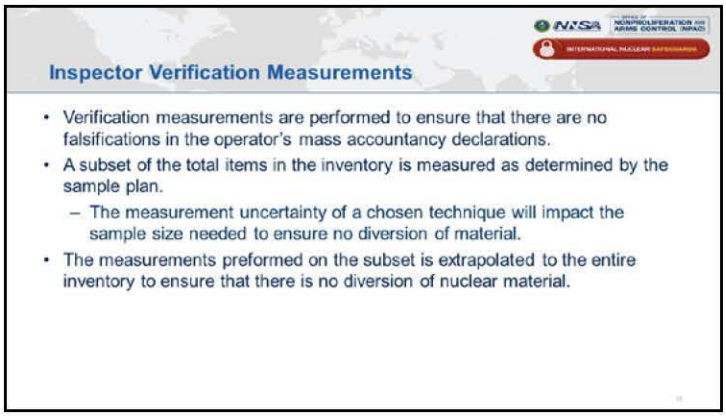

Instructor Notes:

Diversion into D (operator inspector difference) is a concealment method in which the diverter removes an amount of declared material but does nothing to the operator's accounting records to hide the diversion. The accounting records are therefore now false (and have thus been falsified). In this case, the MUF will be statistically consistent with zero.

This type of diversion causes a discrepancy (i.e. defect) between the material declared to be present and the material actually present. The only way to detect the diversion is for the inspector to measure the container(s) from which material was removed and to compare the measured value with the operator's declared value. This scheme is referred to as diversion into D because it can be detected through observation of an unexpectedly large value of the operator – inspector difference. Diversion into D can be concealed if the inspector measurement quality is poor and the uncertainty of D is large.

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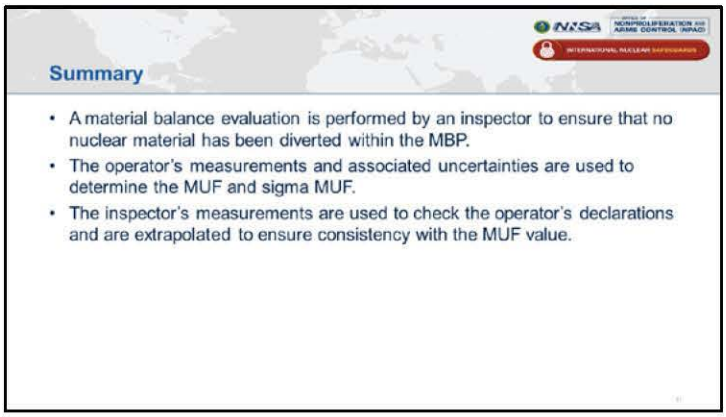

Instructor Notes: